

Quantum theory is the primary mainstay of our understanding and formal description of Nature. Moreover, it constitutes a perfectly empirically confirmed formal construction. One of the main resources within it is the quantum entanglement and its manipulation. Nowadays, we know the quantum entanglement can be realized experimentally, we can control it and exploit for many non-trivial tasks, although we are just at the beginning of our way towards everyday applications. Despite this, we have already formulated the basics of secure quantum communication or quantum computations. In the mentioned possible application one of the central roles is played by the quantum teleportation and unitary operations, being a model of reversible processes, and allowing us for the entanglement manipulations- on these aspects we plan to focus on the submitted proposal.

The first project concerns quantum teleportation protocols which do not require a correction on the receiver's side. It turns out, they play an important role in the simulation of quantum channels, their discrimination, and they can be used as a model of the universal programmable quantum processor. Unfortunately, these protocols are complicated and rather hardly implementable, even for a small number of subsystems. One of the main obstacles is the use of the generalized measurements, which require in practical implementations control over additional degrees of freedom. Here, we plan to relax this constraint by delivering new quantum teleportation protocols without correction and implementable by projective measurements only. We deliver both, the deterministic and probabilistic protocol together with their efficiency analysis.

In the second project, we plan to focus on the problem of implementation of a function of an unknown unitary operation, for example, its inversion. Our goal here is to deliver procedures for the deterministic and probabilistic implementation of the above, with the analysis of efficiency. Proposed solutions will be of a fundamentally different nature than the process tomography, which requires a lot of resources and is rather inefficient in the general situation.

All the research objectives have one common feature - they require methods from group and algebra representation theory and tools from semidefinite programming. Symmetries emerging in the described above projects allow us to attempt to full analytical description and solution.

Summarizing we hope that our researches would have an influence on better understanding the phenomenon of quantum teleportation, implementing a function of unknown unitary operation also from the point of view of potential practical applications, as well as, will develop science discipline of quantum information theory.